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T. FIN TEMPERATURE MEASUREMENTS -- NIKE-CAJUN SOUNDING ROCKET

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Introduction -- A Nike-Cajun two-stage solid propellant sounding rocket was flight-tested to determine the fin temperature of the second-stage under flight conditions. A schematic drawing of the Nike-Cajun Sounding Rocket is shown in Figure 1. A panel-and-shroud fin design was used instead of the extruded-hinge type fin described in References 1, 2, and 3. Details of the panel-and-shroud fin are described in Reference 4. A schematic drawing of the fin assembly is shown in Figure 2. Early problems encountered in panel-and-shroud type fins were attributed to warping, due to machining fins from plate stock. The current panel-and-shroud fin design uses an extruded tapered aluminum sheet which eliminates the warpage problem.

Description of Experiment -- This study was concerned with determining the effect of fin modifications for the Nike-Cajun Sounding Rocket system. The flight vehicle was instrumented to determine fin temperature and basic in-flight performance characteristics. Prior to flight testing, structural load tests on the panel-and-shroud Cajun fin assembly were made, based on anticipated design loads. Figures 3 and 4 show structural load tests being performed--one at room temperature, where the assembly withstood 3,890 pounds per fin at destruction; the other at elevated temperature, where the fin assembly withstood in excess of 1,800 pounds load per fin at 210°F without reaching permanent yield point.

Flight Test, NASA No. 10.49 GT, was performed on March 15, 1961, being launched from Wallops Island, Virginia. The location of fin temperature gauges are shown in Figures 5 and 6 respectively. Longitudinal fairing strips were used to protect the wires leading from the fin temperature gauges to the telemetry section. Fin temperature gauge No. 1 was mounted on a fin panel surface. Since this mid-point of the tang location was critical, the fin thickness could not be reduced to provide a site to mount a recessed gauge. Had excessive bending loads been encountered with the fin temperature gauge recessed, the strength of the fin panel would have been suspect. Fin temperature gauge No. 2, however, was recessed into the fin panel and, therefore, mounted in a region where bending loads were not as critical. The results of the fin temperature tests are shown in Figures 5 and 6. Figure 7 shows the flight velocity as a function of time, both theoretical and measured. The measured velocities were obtained from both accelerometer data and radar skin tracking. Figure 8 presents the altitude-time trajectory--both theoretical and actual.

<u>Results</u> -- Fin temperature gauge No. 1 ceased sensing temperature at approximately 19 1/2 seconds after launch. It is presumed that the gauge was stripped off the surface by the windstream. A comparison between predicted and actual temperatures to that time show reasonably good agreement (see Figure 3). Temperature gauge No. 2 continued to sense temperature in excess of 50 seconds. The agreement between theoretical and actual temperatures is reasonably good, except for approximately 7 or 8 seconds immediately after second-stage burnout (see Figure 6).

Calculations were then made to determine the effective angle of attack capability based on the realized temperatures. These calculations were compared with those based on design assumptions (see Figure 9). These results are presumed conservative inasmuch as the temperature for fin design assumed equilibrium conditions; whereas, in actual flight, the fin temperature appears to undergo a momentary high temperature surge. This high temperature gauge reading may be attributable either to (1) transient effect of stagnation temperature at surface prior to conduction of heat into the fin mass proper or to (2) conduction of heat from the nozzle rather than from aerodynamic heating. From Figure 9, two critical periods occur--at Nike burnout and at Cajun burnout. At both critical periods, the fins can withstand loads approximating 4 degrees angle of attack.

References --

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2. Hansen, W. H. and Fischbach, F. F. - The Nike-Cajun Sounding Rocket, Final Report, March, 1957, Report #2453-1-F, Engineering Research Institute, University of Michigan, Ann Arbor, Michigan.
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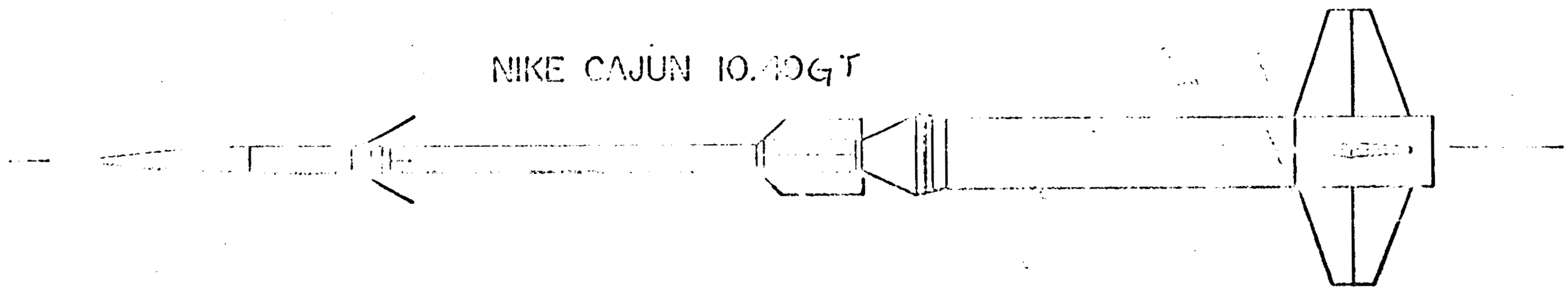
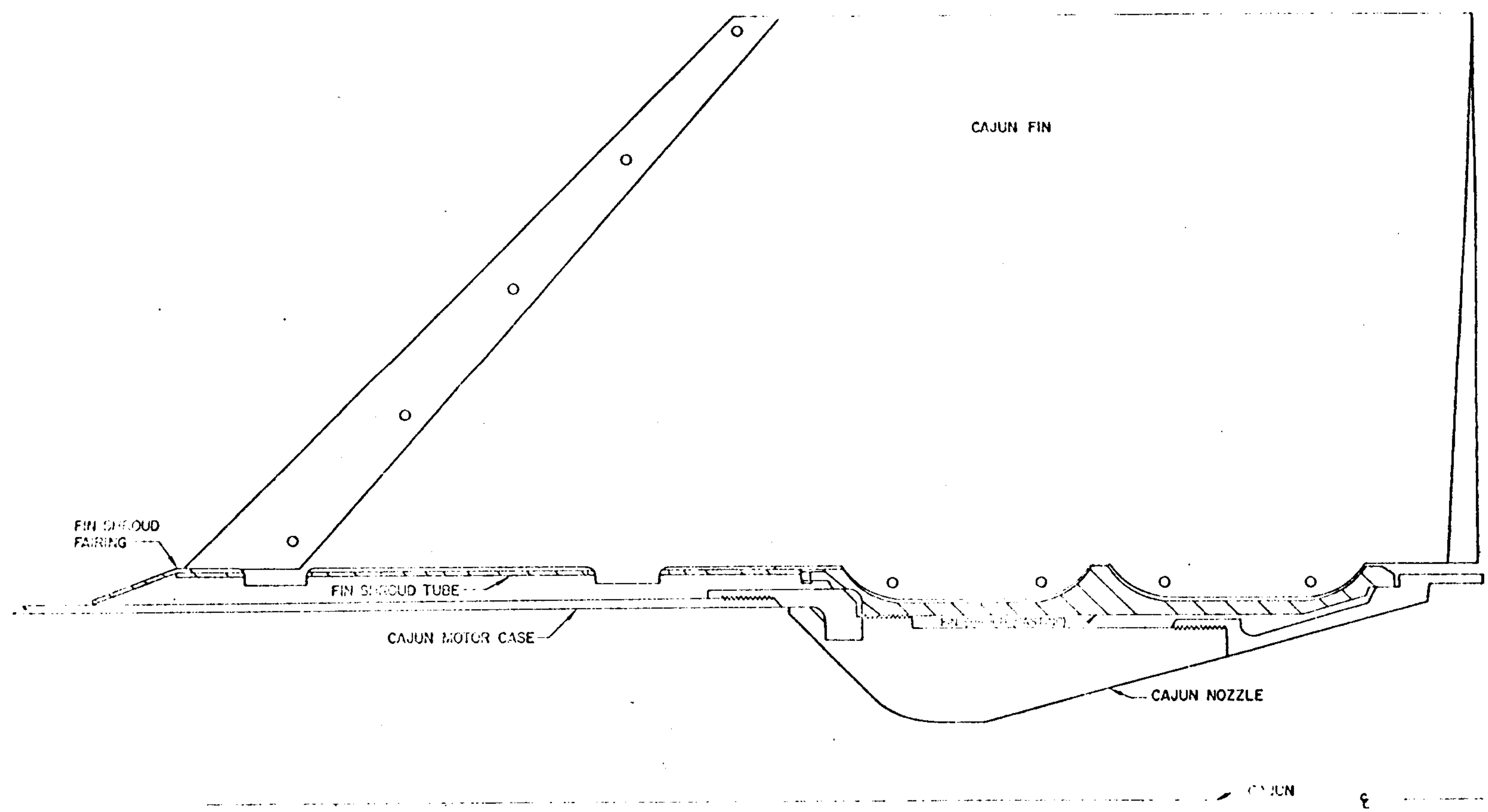


NIKE CAJUN 10.49GT



CAJUN FIN
FIN SHROUD
FAIRING
FIN SHROUD TUBE
CAJUN MOTOR CASE
CAJUN NOZZLE
2

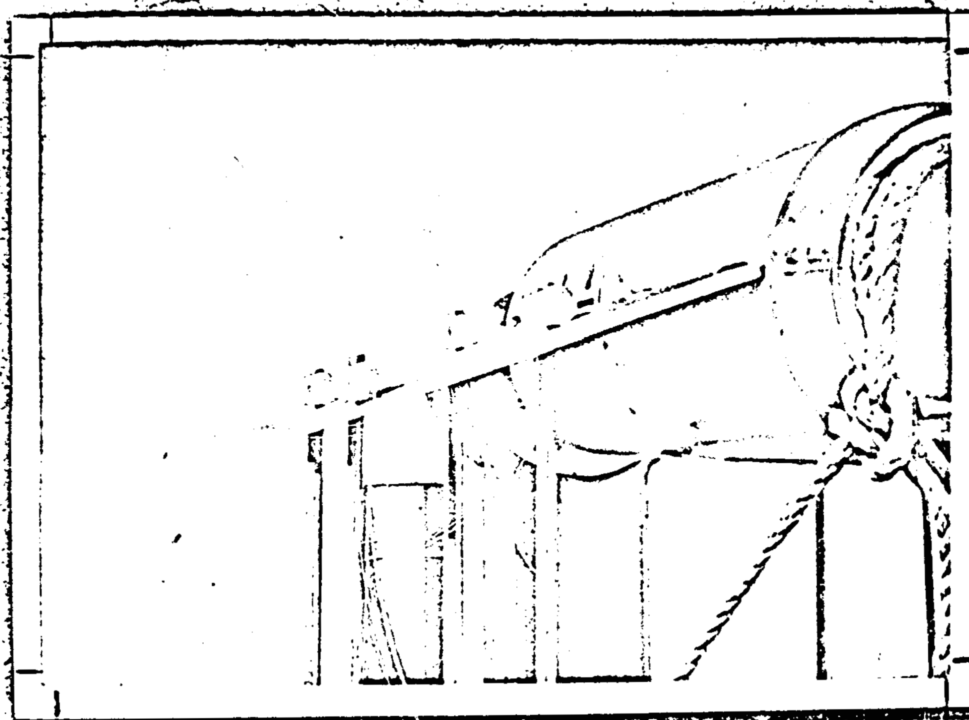
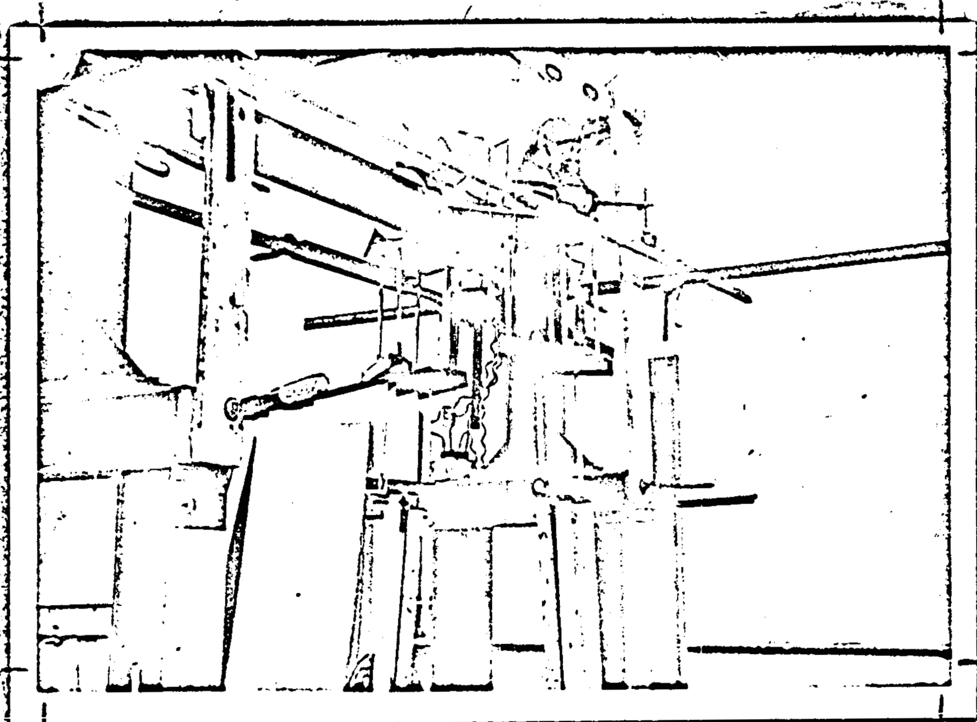


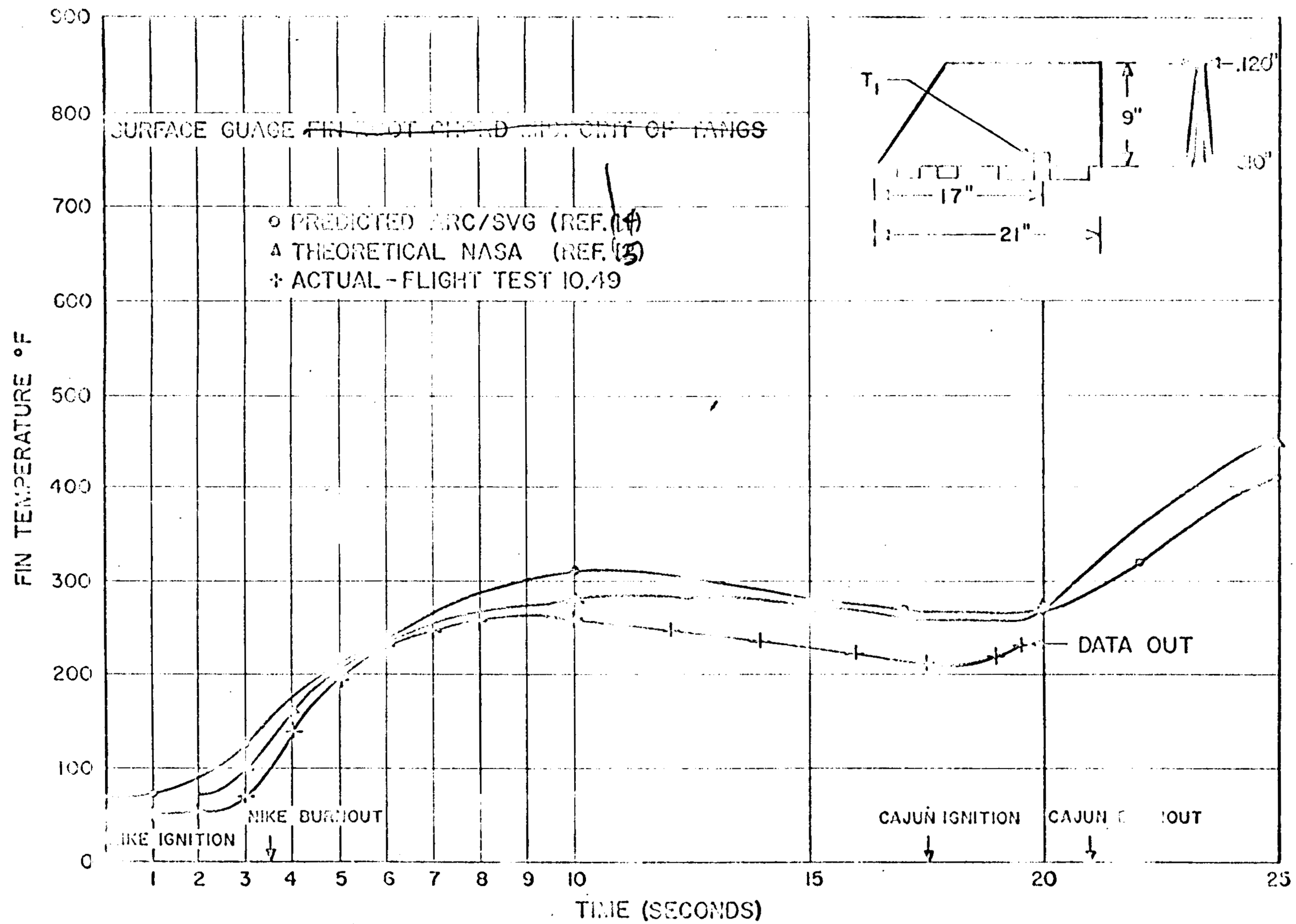
Fig. 3

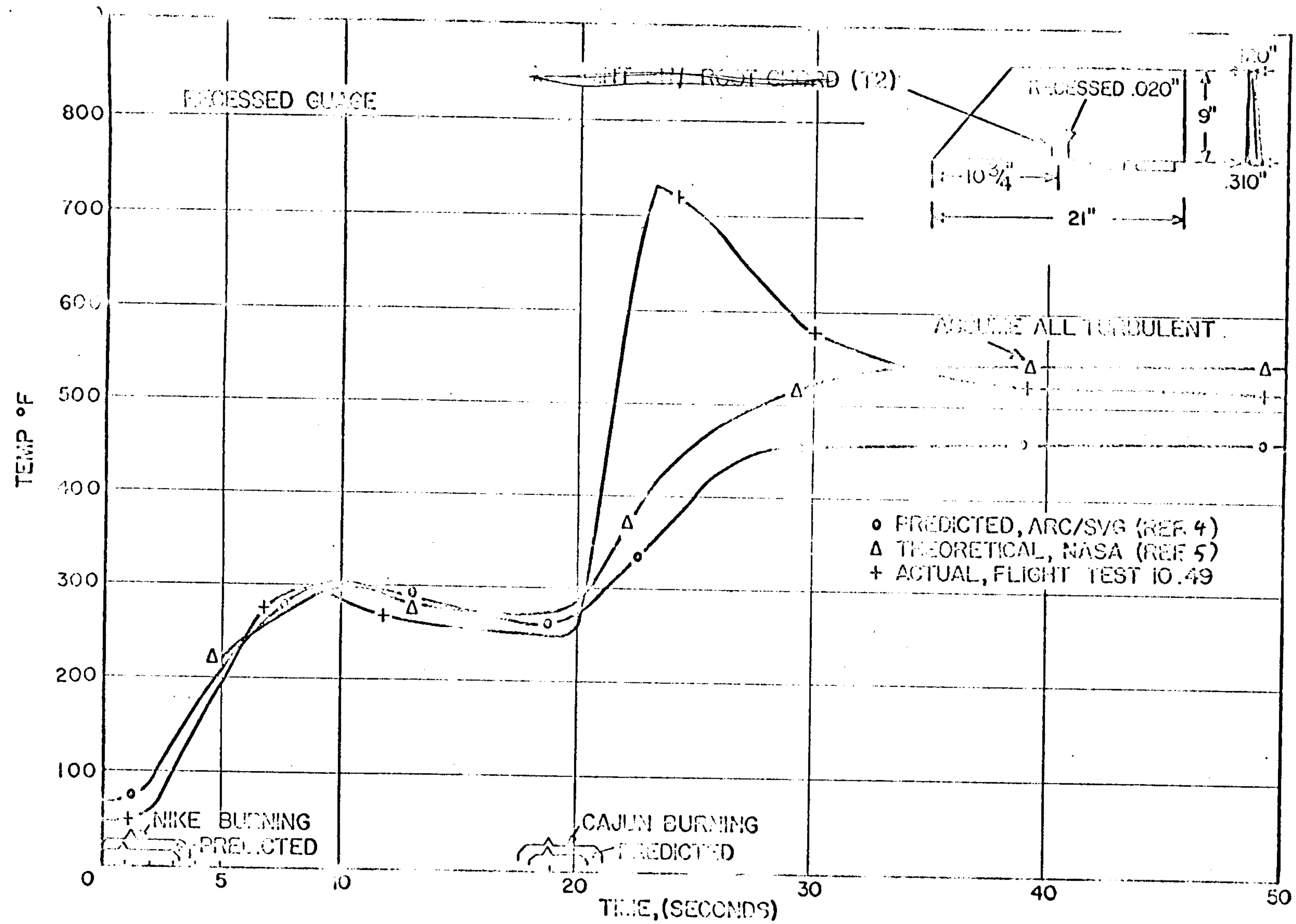


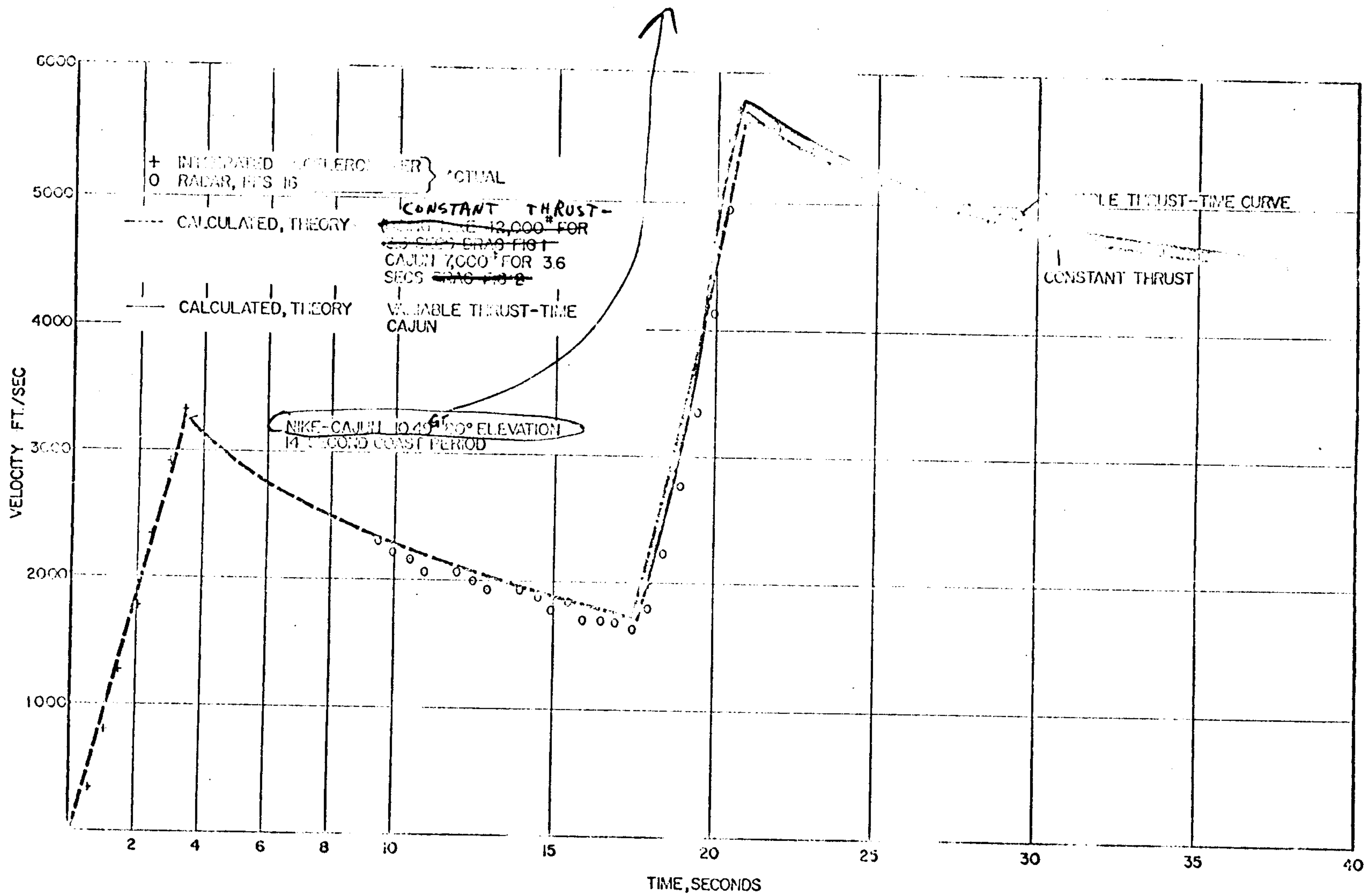
10 1/4

6"

Fig. 4

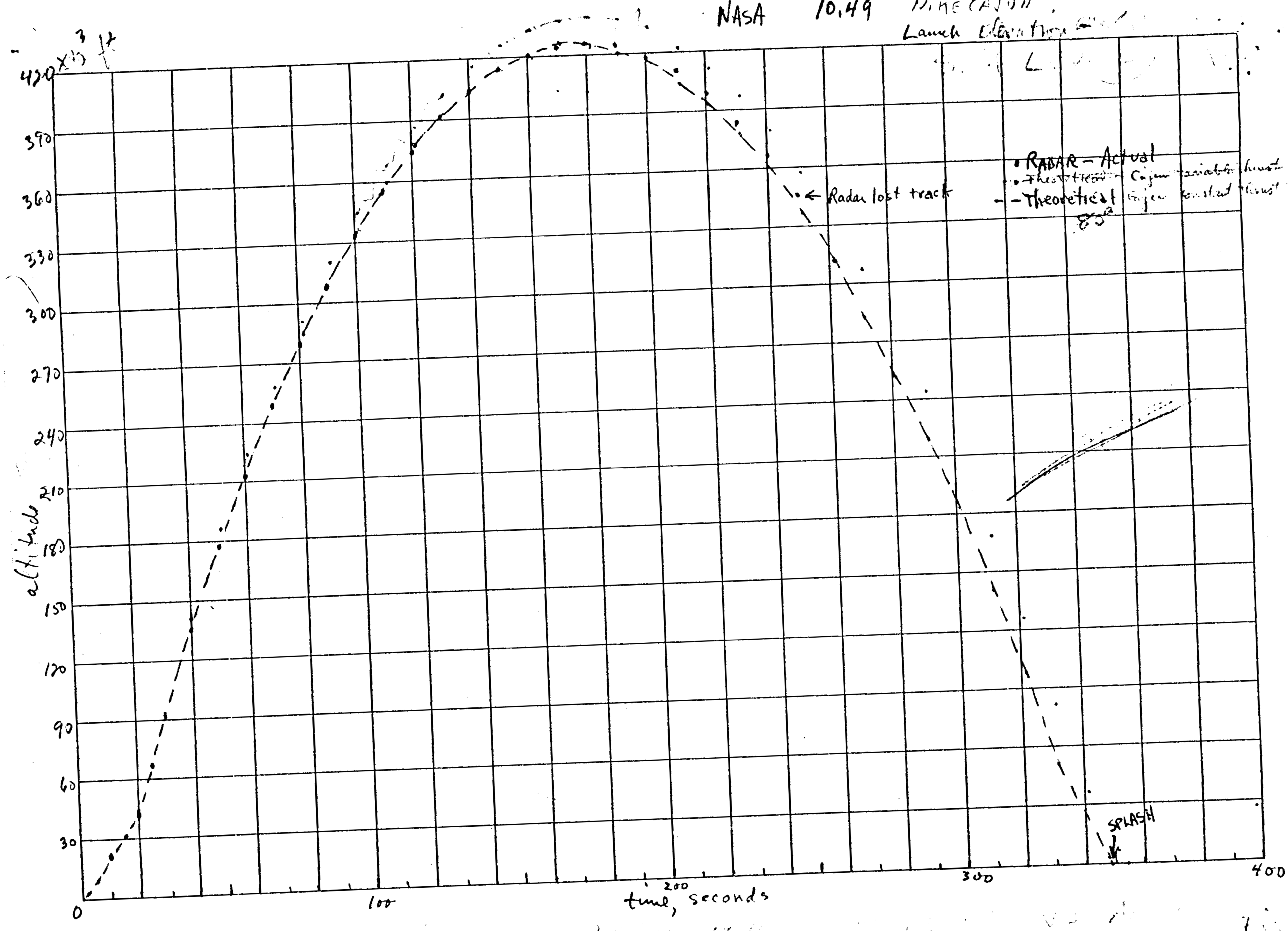

SURFACE GUAGE ~~FIN ROOT CHORD ... OF FANGS~~
o PREDICTED ARC/SVG (REF. 14)
Δ THEORETICAL NASA (REF. 15)
+ ACTUAL - FLIGHT TEST 10.49
T1
9"
.120"
17"
21"
DATA OUT
NIKE BURNOUT
IKE IGNITION
CAJUN IGNITION
CAJUN
OUT
FIN TEMPERATURE °F
TIME (SECONDS)
0
100
200
300
400
500
600
700
800
900
1
2
3
4
5
6
7
8
9
10
15
20
25


TEMP °F
TIME, (SECONDS)
800
700
500
400
300
200
100
0
5
20
30
40
50
9"
.310"
21"
ASSUME ALL TURBULENT
o PREDICTED, ARC/SVG (REF. 4)
Δ THEORETICAL, NASA (REF 5)
+ ACTUAL, FLIGHT TEST 10.49
NIKE BURNING
CAJUN BURNING



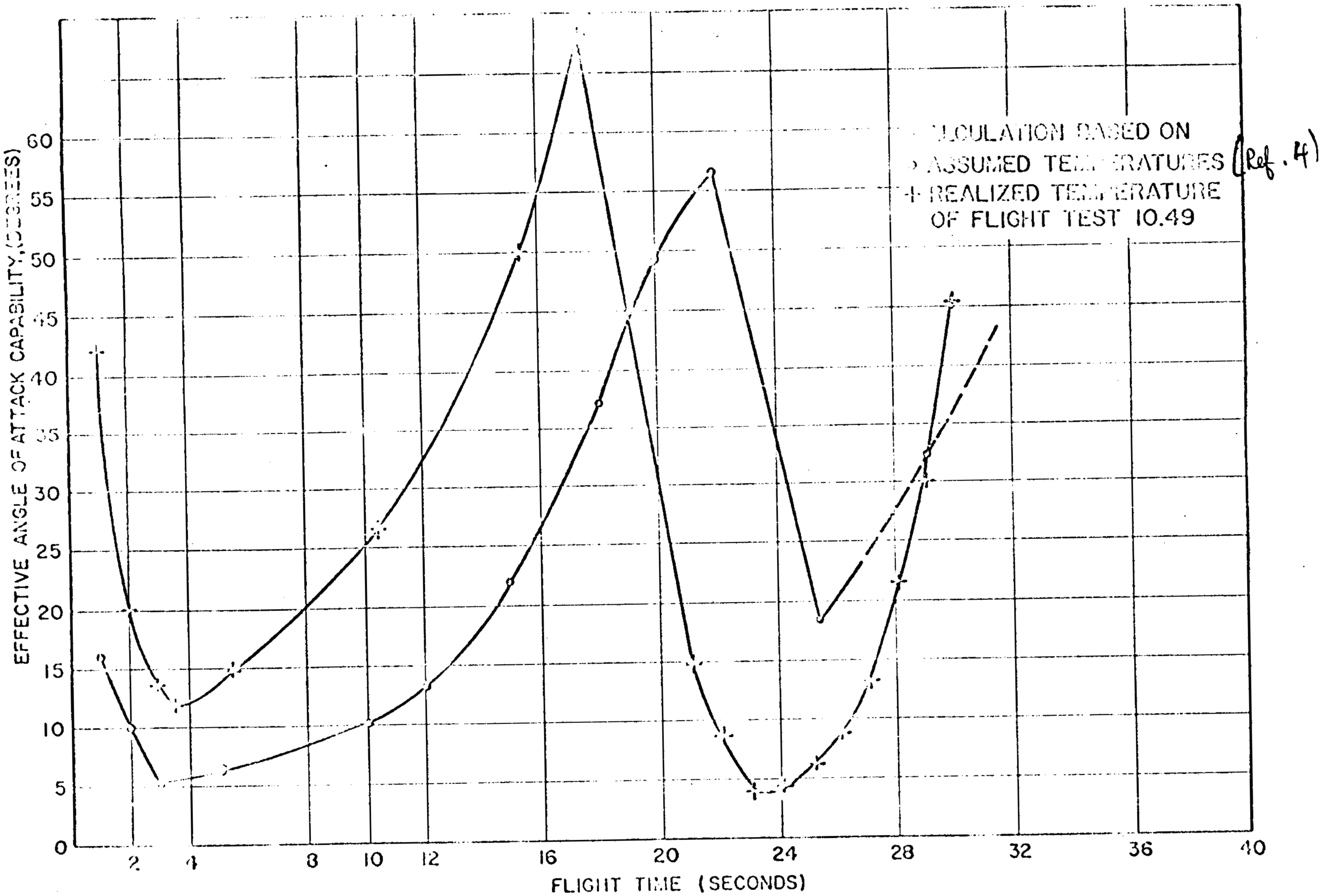
ACTUAL
CALCULATED, THEORY
CONSTANT THRUST-
CAJUN 7,000 FOR 3.6 SECS
CALCULATED, THEORY
VARIABLE THRUST-TIME CAJUN
NIKE-CAJUN 10.49 80° ELEVATION
CONSTANT THRUST
VELOCITY FT./SEC
TIME, SECONDS

NASA 10.49 NIKE CAJUN
Launch Elevation



NO. 4520-L 20X20 TO THE INCH

10.49' NIKE CAJUN


CALCULATION BASED ON
○ ASSUMED TEMPERATURES (Ref. 4)
+ REALIZED TEMPERATURE
OF FLIGHT TEST 10.49
EFFECTIVE ANGLE OF ATTACK CAPABILITY, (DEGREES)
0
5
10
15
20
25
30
35
40
45
50
55
60
2
4
8
10
12
16
20
24
28
32
36
40
FLIGHT TIME (SECONDS)

9